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A New Species of *Dixonius* (Squamata: Gekkonidae) from Kanchanaburi Province, Western Thailand

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Abstract: A new species of the endemic Southeast Asian gekkonid lizard genus *Dixonius* Bauer et al., 1997 is described on the basis of material from Kanchanaburi Province in western Thailand. It is characterized by a distinctive orange tail and a prominent dark stripe from the snout to at least the level of the ear. It occurs sympatrically with its larger and more widely distributed congener, *D. siamensis*.

Key words: *Dixonius*; Gekkonidae; New species; Kanchanaburi; Thailand

INTRODUCTION

The gekkonid genus *Dixonius* Bauer et al., 1997 was erected to accommodate Southeast Asian leaf-toed geckos previously assigned to the polyphyletic and nearly cosmopolitan *Phyllodactylus*. The phylogenetic affinities of *Dixonius* to other gekkonids remain uncertain, but it does not appear to be especially closely related to other clades of leaf-toed geckos that have been identified (Bauer et al., 1997). The possible generic distinctness of the group was first noted by Annandale (1905b), who considered the presence of precloacal pores as highly distinctive within *Phyllodactylus*. Dixon (1964), subsequently noted that *siamensis* exhibited a reduced manual phalangeal formula of 2:3:4:4:3. Russell (1972) demonstrated that there was in fact no phalangeal loss in digit IV of the manus, but identified a unique reduction in size of phalanx II of this digit. Bauer et al. (1997) subsequently diagnosed *Dixonius* relative to other leaf-toed geckos on the basis of these precloacal pore and digital characters, as well as the tuberculate condition of the dorsum and the proximal bifurcation of the hypoischium.

Two species of *Dixonius* have generally been recognized by recent reviewers (Wermuth, 1965; Kluge, 1991, 1993, 2001; Bauer

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et al., 1997; Rösler, 2000). The larger and more widespread form, *D. siamensis* (Boulenger, 1898) was described from specimens from "Dung Phya Fai, Siam" [=Dong Paya Fai Mountains, Sara Buri and Nakhon Ratchasima Provinces, Thailand]. Two additional leaf-toed geckos described early in the 20th Century are currently placed in the synonymy of *D. siamensis*. Mocquard (1904) described *P. paviei* from "Vatana (Siam)", but provided no differential diagnosis with respect to *P. siamensis*, as he was apparently unaware of Boulenger's (1898) earlier description. Annandale (1905a), although cognizant of *Phyllodactylus siamensis*, did not know of *P. paviei* when he described *P. burmanicus* from "Tavoy" (Dawei, Taninthayi State, Myanmar). He proposed several diagnostic differences between his form and *P. siamensis*, including smaller dorsal tubercles and a smaller number of subdigital lamellae. However, the accumulation of many additional specimens has revealed that the purportedly diagnostic features of both *P. burmanicus* and *P. paviei* fall within the range of variation of *D. siamensis*.

A largely patternless form first noted by Smith (1935), however, was subsequently described by Taylor (1962: 215) as *Phyllodactylus melanostictus*, with its type locality at "Mauk Lek Road-Camp (Friendship Highway) Sara Buri" Thailand (corrected to Muak Lek by Taylor, 1962: 218; both spellings were also given by Taylor, 1963). This taxon differs from *D. siamensis* chiefly in its largely patternless dorsum and possession of a distinct dark line from the snout to the shoulder and thence along the flank to the tail. In addition, its specific distinctness is supported by its occurrence in sympatry with *D. siamensis* in Sara Buri and Nakhon Ratchasima provinces in central Thailand (Taylor, 1962, 1963; Grossmann and Ulber, 1990; Chan-ard et al., 1999). This form has also been reported from Ma Da, Vietnam (Bobrov, 1992), although whether the *D. melanostictus* is continuously distributed in the intervening areas or the Vietnamese population represents a disjunct population, or a similar but distinct species remains to be investigated.

Although *Dixonius siamensis* is best known from Thailand, where it occurs from Songkhla (7°N), south of the Isthmus of Kra (Taylor, 1963), north to at least Chiang Mai (19°N) (Grossmann et al., 1996; Manthey and Grossmann, 1997), its range extends from southern Myanmar (Annandale, 1905a, b) to the Lao Peoples Democratic Republic (Stuart, 1999) and Vietnam (Smith, 1935; Bourret, 1939; Szczerbak and Nekrasova, 1994). Its occurrence in Cambodia has not been verified, but the proximity of both Thai and Vietnamese localities to the borders of Cambodia (Szczerbak and Nekrasova, 1994; Grossmann et al., 1996) suggests that it is likely to range across the width of this country as well. This broad distribution, along with obvious geographic variation in color pattern (Taylor, 1963) raises the possibility that *D. siamensis*, as presently construed, may actually represent a complex of similar species.

This hypothesis is supported by Ota et al. (2001), who have demonstrated that a minimum of two chromosome forms (2n=40 and 2n=42) exist among Thai populations of *D. siamensis*, with a female from one population (from Mae Yom, northern Thailand) also exhibiting a heteromorphism indicative of a ZW sex chromosome system. Such karyotypic diversity strongly suggests that more than one evolutionary unit is presently included under *D. siamensis* (Ota et al., 2001). This also raises the possibility that one or both of the two names currently included in the synonymy of *D. siamensis* may be applicable to a valid species. Such a hypothesis cannot be adequately investigated without fine scale sampling of material for both morphological and molecular analysis from throughout the range of *Dixonius*, including each of the type localities. While such a revision is not yet possible, we here identify and describe a distinctive form of *Dixonius*, first collected in 1992 by Gernot Vogel from Kanchanaburi Province, western Thailand where it occurs in sympatry with typical *D. siamensis*.

MATERIALS AND METHODS

The following measurements were taken with Brown and Sharpe Digit-cal Plus digital calipers (to the nearest 0.01 mm): snout-vent length (SVL; from tip of snout to vent), head length (HeadL; distance between retroarticular process of jaw and snout-tip), head width (HeadW; maximum width of head), head height (HeadH; maximum height of head, from occiput to underside of jaws), orbital diameter (OrbD; greatest diameter of orbit), nares to eye distance (NarEye; distance between anteriormost point of eye and nostril), snout to eye distance (SnEye; distance between anteriormost point of eye and tip of snout), eye to ear distance (EyeEar; distance from anterior edge of ear opening to posterior corner of eye), ear length (EarL; longest dimension of ear), internarial distance (Internar; distance between nares), and interorbital distance (Interorb; shortest distance between left and right supraciliary scale rows), trunk length (TrunkL; distance from axilla to groin measured from posterior edge of forelimb insertion to anterior edge of hindlimb insertion), forearm length (ForeaL; from base of palm to elbow), crus length (CrusL; from base of heel to knee), tail length (TailL; from vent to tip of tail), tail width (TailW; measured at widest point of tail). Scale counts and external observations of morphology were made using a Nikon SMZ-10 dissecting microscope. Radiographic observations were made using a Faxitron enclosed radiographic unit.

Comparisons were made with museum material in the collections of the California Academy of Sciences (CAS), Field Museum of Natural History (FMNH), and Institut Royal des Sciences Naturelles de Belgique (IRSNB) (see Appendix), as well as original published descriptions and descriptions provided in broader faunal treatments (e.g., Smith, 1935; Taylor, 1963).

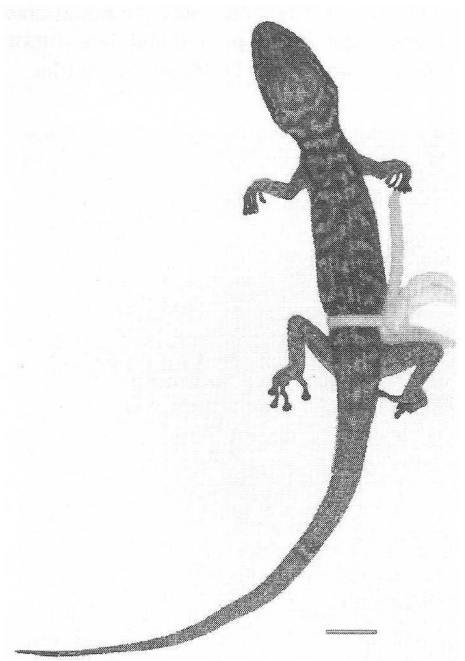

FIG. 1. Holotype of *Dixonius hangseesom*, sp. nov. (CUMZ R 2003.58) from Sai Yok, Kanchanaburi Province, Thailand. Bar equals 5 mm. Photo by Aaron M. Bauer.

Dixonius hangseesom, sp. nov.
Figs. 1–6

Holotype

Chulalongkorn University Museum of Zoology (CUMZ) R 2003.58 (Fig. 1); Thailand, Kanchanaburi Province, Sai Yok District, near Ban Tha Sao (Sai Yok Noi Waterfall), 14°06'N 99°25'E; Coll. M. Sumontha, 6 September 2002.

Paratypes

CUMZ R 2003.57, CUMZ R 2003.60, CUMZ R 2003.6, Institut Royal des Sciences Naturelles de Belgique (IRSNB) 2587; same data as holotype. Zoologisches Museum

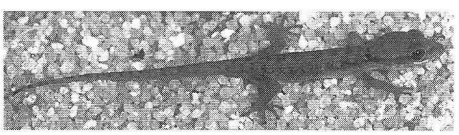

FIG. 2. Juvenile captive specimen *Dixonius hangseesom*, sp. nov. (live collection of W. Grossmann) illustrating the drab tail coloration of young specimens. Photo by Wolfgang Grossmann.

Berlin (ZMB) 65437; Thailand, Kanchanaburi Province, Sai Yok National Park, Coll. G. Vogel, 28 September 1992.

Diagnosis

Dixonius hangseesom may be distinguished from non-congeneric leaf-toed geckos on the basis of the possession of precloacal pores by males and by the unique configuration of the phalanges of the manus. It may be diagnosed from *D. siamensis* by its smaller size (maximum 42 mm vs 57 mm; Manthey and Grossmann, 1997) and presence of a bold dark stripe through the eye, cross-banded or reticulate dorsal pattern, and an orange-colored tail (in life). It is also distinguished by its more irregular (with dorsal tubercles sometimes scattered on flanks and often with keels oriented obliquely to body axis) and partly imbricating dorsal scalation (vs smaller, regular, non-overlapping, more conical tubercles) and broader terminal scansors (approximately twice mid-digital toe width vs 1.5 times mid-digital toe width). These features would also diagnose the new species from *D. paviei* and *D. burmanicus*, should future research revalidate these taxa.

FIG. 3. Living specimen of adult male *Dixonius hangseesom*, sp. nov. from Sai Yok, Kanchanaburi Province, Thailand. Note the bright orange tail, crossbanded dorsal pattern and dark markings on sides of head. Photo by Montri Sumontha.

FIG. 4. Male paratype (ZMB 65437) of *Dixonius hangseesom*, sp. nov. shortly after capture as a 33 mm SVL subadult-adult. Compare tail coloration and dorsal pattern with Fig. 5. Photo by Wolfgang Grossmann.

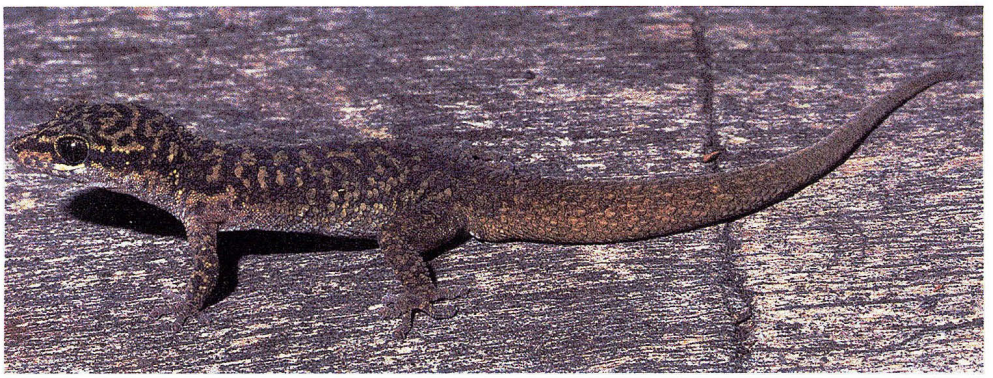

FIG. 5. Male paratype (ZMB 65437) of *Dixonius hangseesom*, sp. nov. after seven years and three months in captivity. Note the fusion of dorsal dark markings and the drab tail in comparison to the same specimen earlier in life (Fig. 4). Photo by Wolfgang Grossmann.

Dixonius hangseesom shares the dark eye stripe with *D. melanostictus* but unlike this form has a dorsal pattern with alternating light and dark markings (vs an essentially unpatterned dorsum, or pale stripes or longitudinal series of light spots), a greater number of midbody scale rows (12–14 rows of tubercles and 22–26 ventrals vs 10–11 rows of tubercles and 22 ventrals; Taylor, 1963), and smaller body size (maximum 42 mm SVL vs 50 mm SVL).

Description of holotype

Adult male, snout-vent length 36.92 mm. Head relatively long (HeadL/SVL ratio 0.29), wide (HeadW/HeadL ratio 0.60), not markedly depressed (HeadH/HL ratio 0.40), distinct from slender neck. Lores and interorbital region weakly inflated, canthus rostralis relatively prominent. Snout moderately short (SnEye/HeadL ratio 0.37), rounded; longer than eye diameter (OrbD/SnEye ratio 0.69); scales on snout and forehead small, hexagonal to rounded, flattened, with smooth or slightly rugose surface and a low median keel, some conical; scales on snout larger than those on occipital region. Eye moderately large (OrbD/HeadL ratio 0.26); pupil vertical with crenelated margins; supraciliaries short, without spines. Ear opening oval, obliquely oriented, relatively large (EarL/HeadL ratio 0.08); eye to ear distance somewhat greater than diameter of eyes. Rostral approximately two-thirds deep (1.07 mm) as wide (1.63 mm), incompletely divided dorsally by a straight rostral groove; two somewhat enlarged supranasals in broad contact anteriorly, separated by a single, small internasal posteriorly; rostral in contact with supralabial I, supranasals, and internasal; nostrils round, each surrounded by supranasal, rostral, first supralabial, and two enlarged postnasals; one row of small scales separate orbit from supralabials. Mental triangular, wider (1.97 mm) than deep (1.51 mm); two pairs of enlarged postmentals, anteriormost approximately 2.5 times larger than posterior, posterior approximately 4–6 times larger than adjacent throat scales; each anterior postmental bordered anteriorly by mental, medially by other anterior postmental, anterolaterally by first infralabial, posterolaterally by second postmental; the pair collectively bordered posteromedially by a row of three throat scales; posterior postmentals each bordered posteriorly by series of 4–5 granules. Supralabials to midorbital position 6; enlarged supralabials to angle of jaws 8; infralabials 6 enlarged and two very small; interorbital scale rows across narrowest point of frontal bone 10.

Body slender, elongate (TrunkL/SVL ratio 0.43) with no ventrolateral folds. Dorsal scales strongly heterogeneous: small, irregular, flattened to conical scales interspersed among large (4–6 times size of adjacent scales), strongly

keeled subimbricate tubercles arranged in 12 more-or-less regular longitudinal rows extending on to tail; paravertebral tubercles especially well-developed; occasional tubercles with keels oriented obliquely to the body axis; flanks covered with irregular smooth scales. Ventral scales comparable in size to dorsal tubercles, smooth, imbricate; free margins rounded and distinctly ctenate; increasing in size from throat to chest to abdomen, somewhat smaller in precloacal region; midbody scale rows across belly to lowest rows of tubercles, 26; gular region with relatively homogeneous, granular scales. Eight precloacal pores in continuous series; pore-bearing scales not enlarged relative to adjacent scale rows; scales in row immediately posterior to pore-bearing row 2–3 times size of other scales of cloacal region. No femoral pores or enlarged femoral scales. Scales on palm and sole small, smooth, rounded to oval; scalation on dorsal aspects of hind limbs with enlarged, subimbricate, keeled tubercles on thigh and conical (or keeled) scales on shanks.

Fore and hindlimbs short, slender (ForeaL/SVL ratio 0.13; CrusL/SVL ratio 0.16); digits slender, dilated distally, all bearing robust, slightly recurved claws; basal subdigital lamellae narrow, without scansorial surfaces (6–8–10–9–9 manus; 6–9–11–13–13 pes); setae-bearing lamellae restricted to enlarged, distal, "leaf-like" scansors; interdigital webbing absent. Relative length of digits (manus): III>IV~II>V>I; (pes): IV>III>V>II>I.

Mostly original (terminal 19.97 mm regenerated) tail long, slender, tapering to tip; longer than snout-vent length (TailL/SVL ratio 1.34); whorls of keeled scales on dorsum of basal portion of tail, lateral and distal scales lacking well-developed keels; small, irregular scales separating keeled tubercles in some places; ventral scales enlarged into transverse plates. Regenerated portion of tail with more-or-less uniform, smooth, flattened, subimbricate dorsal scales; ventral scales as in original, but somewhat irregular in outline. Series of two small, smooth, raised postcloacal spurs on each side of tailbase.

Osteology

Parietal bones paired; stapes imperforate. Phalangeal formulae 2–3–4–5–3 for manus and 2–3–4–5–4 for pes. Presacral vertebrae 26, including 3 anterior cervical (without ribs), one lumbar, and 2 sacral vertebrae; 5 pygal and 7.5 post pygal caudal vertebrae to point of regeneration in Holotype and IRSNB 2587 (21.5 post-pygal vertebrae in CUMZ R 2003.6; 10.5 in ZMB 65437; 9.5 in CUMZ R 2003.60; 3.5 in CUMZ R 2003.57). Holotype and male paratypes with one pair of crescentic cloacal bones. Endolymphatic sacs enlarged extracranially in the two female paratypes, but not in males. Fusion of epiphyseal plates evident in all specimens except CUMZ R 2003.60 (partly fused).

Color in preservative

Boldly patterned, especially on head and anterior trunk, with contrasting cream and mid- to dark brown markings. Head with a series of concentric alternating light and dark arcs behind orbits; thick dark band from nostril, through orbit and above ear, fusing with dorsal dark brown markings on side of neck, this stripe bordered above by a narrower white stripe extending to level of ear; labial scales predominantly brown, white at sutures. Trunk predominantly brown with irregular cream cross bands, becoming less sharply defined on flanks and over sacrum. Limbs mottled. Tail pale brown with specklings of darker pigment; a single light band at junction of original with regenerate. Venter cream with isolated dark flecks on almost all scales, very faint along ventral midline, darker under limbs and tail and at flank margins.

Color in life

(Based on paratype ZMB 65437, captive specimens, and photographs of specimens in the wild). In life (Figs. 2–6) the dorsal base color is beige to grayish to yellowish tan with dark brown markings. A series of scattered whitish scales extending along dorsolateral margins of body from posterior margin of white supra-auricular stripe to tail base (not

evident in preserved specimens). There is a marked ontogenetic change in coloration. In juveniles (Fig. 2) the dark markings on the body may be more scattered than in adults. The tail in juveniles is also less brightly colored, being mid-brown with alternating beige to pale orange bands or spots. In older subadults and adults the tail takes on a distinctly orange base color that contrasts with that of the body. The tail may bear more-or-less regular lighter, yellowish bands with dark brown margins (Fig. 3), or may be a more uniform orange-brown (Fig. 4). In older adults there is maximal fusion of the dark dorsal markings and the tail darkens from orange to mid-brown (Fig. 5).

Variation

Comparative mensural data for the holotype and paratypes are presented in Table 1. The paratypes similar to holotype in most respects except as noted. CUMZ R 2003.6 with digits IV–V of right manus and digit III of left manus missing, digits II–IV of right pes missing, and digit V of same foot damaged. Female paratypes lack precloacal pores and cloacal bones. Precloacal pores in continuous series of seven (CUMZ R 2003.6) or eight (ZMB 65437), or with a single poreless scale separating left and right series of three pored scales (IRSNB 2587) in male paratypes. Dorsal tubercle rows 12–14, ventral scale rows 22–26, scattered tubercles present on flanks in ZMB 65437 (which possesses the most heterogeneous scalation of the type series). Dorsal coloration similar to holotype but darker brown and pattern more reticulate in ZMB 65437 (see also Fig. 5), paler and markings more regularly transversely arranged in remaining paratypes (see also Figs. 3, 6). Venter of ZMB 65437 moderately heavily pigmented, yielding a dusky appearance. Ontogenetic variation in tail coloration discussed above.

TABLE 1. Mensural data for the type series of *Dixonius hangseesom*, sp. nov. Abbreviations as in Materials and Methods, all measurements in mm.

	Holotype	Paratypes				
	CUMZ R 2003.58	CUMZ R 2003.57	CUMZ R 2003.60	CUMZ R 2003.6	ZMB 65437	IRSNB 2587
Sex	male	female	female	male	male	male
SVL	36.92	39.13	36.55	39.20	42.12	36.68
HeadL	10.63	10.63	11.08	10.99	11.29	10.24
HeadW	6.40	6.78	6.22	6.57	7.62	6.25
HeadH	4.30	4.51	4.23	4.24	4.65	4.20
OrbD	2.73	2.61	2.83	2.61	3.03	2.57
EyeEar	3.19	2.92	2.65	2.79	3.02	2.57
SnEye	3.96	4.28	4.21	4.38	4.37	4.02
NarEye	2.97	3.04	2.61	2.66	2.99	2.62
Interorb	3.65	3.93	3.23	3.25	3.89	3.26
EarL	0.89	0.89	0.84	0.77	0.84	0.91
Internar	0.95	1.27	0.90	0.92	1.21	0.89
TrunkL	15.70	16.31	14.87	17.14	18.41	17.50
ForeaL	4.88	5.07	5.19	5.62	5.54	5.11
CrusL	5.94	6.28	6.03	6.14	6.22	5.67
TailL (regen.)	49.51	33.51	33.77	46.54	51.49	47.56
TailW	3.29	3.39	3.29	3.42	4.38	3.83

Etymology

The specific epithet is derived from a transliteration of the Thai "hang" meaning tail, "see" meaning color, and "som" meaning orange. It refers to the most obvious diagnostic feature of the species, its orange tail color. The transliteration follows that of Allison (1978) as used by Cox (1991).

Observations in captivity

One paratype of *Dixonius hangseesom* (ZMB 65437), captured when about 33 mm SVL, lived ten years and two months in captivity, maintained in a daily and seasonally variable temperature regime of 16.5 C–29.8 C in the care of W. Grossmann. During this period this animal was strictly crepuscular and nocturnal in its activity cycle. It was maintained on a diverse diet of food insects including crickets, locusts, fruit flies, wax worms, and meal worms. The orange tail of this gecko became darker with age, becoming mid-brown during the last three years of its life (Figs 4–5). During the last year of its life the behavior of the specimen changed and daytime emergence from its retreat site was noted. Ultimately the gecko's movements became slowed and in the last week of life it became uncoordinated. Given the extreme longevity of this specimen—comparable to the maximum age achieved by most small-bodied gekkonids (Bowler, 1977; Rösler, 1982, 1987), we assume that this behavioral alteration and motor degradation was the result of senescence rather than a specific pathology and that *D. hangseesom* in the wild is unlikely to reach this advanced age.

Distribution and natural history

To date *Dixonius hangseesom* has only been found in Kanchanaburi Province in western Thailand. The CUMZ and IRSNB paratypes were collected on a limestone hill in bamboo forest (Fig. 7). The ZMB paratype was collected under stones after heavy rainfall near the edge of primary forest. The new species occurs sympatrically with *D. siamensis* in some localities, but it occupies more mesic microhabitats and has been found at higher elevations when the two species co-occur. *Dixonius siamensis* is typically found in drier, rocky locales, although it can occupy a fairly broad spectrum of habitats from sea level to at least 700 m (Manthey and Grossmann, 1997; Pauwels et al., 2003).

Among the other reptiles found sympatrically with the types from Sai Yok are *Cyrtodactylus peguensis*, *Gekko* cf. *siamensis*, *Gehyra fehlmanni*, *Calotes mystaceus*, *Lygo-*

FIG. 6. Adult *Dixonius hangseesom*, sp. nov. in situ on limestone at Sai Yok, Kanchanaburi Province, Thailand. Photo by Nonn Panitvong.

FIG. 7. Pathway in bamboo forest at type locality of *Dixonius hangseesom*, sp. nov. near Ban Tha Sao, Sai Yok, Kanchanaburi Province, Thailand. Photo by Montri Sumontha.

soma quadrupes, *Ramphotyphlops braminus*, *Pareas carinatus*, *Ahaetulla prasina*, *Oligodon* cf. *fasciolatus*, *Ptyas mucosa*, and *Trimeresurus kanburiensis* (M. Sumontha, G. Vogel, unpublished data; C. Schäfer, pers. comm.). Sai Yok is also the only known locality for the recently described *Cyrtodactylus tigroides*, which is apparently restricted to limestone habitats (Bauer et al., 2003). Unfortunately, existing information regarding *Dixonius hangseesom* is insufficient to determine if it is another limestone substrate endemic or if its distribution extends out of Kanchanaburi Province, either eastwards, or westwards into Myanmar. However, Kanchanaburi and adjacent areas do harbor a number of endemic species including Kitti's hog-nosed bat, *Craseonycterus thonglongyai* Hill, 1974 (Humphrey and Bain, 1990) and the pitviper *Trimeresurus kanburiensis* Smith, 1943 (Cox, 1991). The discovery of two new geckos from the province, serves to further highlight the importance of Kanchanaburi as a center of diversity and endemism within Thailand.

Dixonius hangseesom is threatened by the pet trade and is available, along with *D. siamensis*, from animal sellers at Jatujak Market in Bangkok. It is hoped that its identification as a distinct species will permit its eventual protection.

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APPENDIX

Comparative Material Examined

All material from Thailand.

Dixonius melanostictus

FMNH 178232; Sara Buri Province.

Dixonius siamensis

Gernot Vogel (GV), 2 uncatalogued specimens; Kanchanaburi Province, Nongbuwa Village near Kanchanaburi. GV, uncatalogued specimens, Tak Province, near border with Myanmar, ca. 600 m. IRSNB 15155; Phetchaburi Province, Kaeng Krachan District, Ban Khao Kling. IRSNB 16642; Chiang Mai Province, Muang District, Chiang Mai City. IRSNB 16643; Chiang Mai Province, Doi Saket District, Doi Saket. IRSNB 16645; Phetchaburi Province, Ban Lat District, Ban Nong Ipho, foot of Khao Loun. CUMZ R 2003.59; Kanchanaburi Province, Sai Yok District, near Sai Yok Noi Waterfall. FMNH 177730, 177732, 177735, 177766, 177796; Chon Buri Province; CAS 95254–57; Tak Province, Yan Hee Dam.

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